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ABILITY OF RED BLOOD CORPUSCLES TO EFFECT PHAGOCYTOSIS

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Until the 1920s, it was assumed that the sole function of red blood corpuscles was temporary fixation of oxygen and transportation of oxygen [and carbon dioxide]. In 1923-25, B. Zbarskiy (1) demonstrated that erythrocytes are capable of binding aminoacids and other products of the decomposition of proteins, including toxins. On the basis of a number of investigations, Zbarskiy concluded that there is a connection between the adsorptive capacity of erythrocytes with reference to some toxin and the sensitivity of the species of animal in question to that particular toxin.

I. I. Lintvarev (2) showed that the erythrocytes of the pigeon bind diphtheria toxin, freeing the serum from it. O. B. Lepeshinskaya (3) investigated in detail the effect of various substances on the permeability of the outer covering of erythrocytes. This enabled her to approach an understanding of phenomena connected with chemical metabolism occurring in the organism. N. M. Nikolayev (4) considers that as a result of an incomplete decay of microorganisms in the body, toxic products remain, and that these products, being substances of the protein class, are adsorbed by the erythrocytes. This modifies the erythrocytes, so that they are phagocytized by leucocytes or cells of the reticuloendothelial system.

Nikolayev attaches considerable importance to the phagocytosis of erythrocytes and their fragments and regards this process as a link in the hemoglobin cycle. L. A. Zil'ber and L. M. Yakobson (5) isolated from erythrocytes a substance they named erythrin which has antibiotic properties. According to Zil'ber and Yakobson, erythrin brings about suffocation of bacteria coming into contact with it, i.e., suppresses the action of bacterial dehydrogenases.

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In the light of the above-enumerated results, the function of the red blood constituent in immunity must be evaluated from an entirely different standpoint. The erythrocytes no longer can be considered as not participating in the complex system of interaction between the macroorganism and microorganisms and toxins.

Since the above-mentioned results prove this participation of erythrocytes in an indirect manner only, I decided to investigate the function of erythrocytes in various stages of phylogenesis to obtain a direct proof. In the course of the experiments, by determining the phagocytary index according to Ye. N. Mosyagina (6) it was established that erythrocytes of the frog phagocytize staphylococcus aureus or Bact. coli within three fourths of an hour at room temperature in vitro. Erythrocytes of frogs into whose dorsal lymph sack staphylococci or coli bacilli had been introduced, were well loaded with the microorganisms in question. Furthermore, numerous investigations both in vivo and vitro demonstrated that the ability of frog erythrocytes to phagocytize microorganisms is enhanced by treating the frog with the blood of a guinea pig, rinsed erythrocytes of a rabbit, or serum of a rabbit in such a manner that these preparations are introduced into the lymphatic sack or after a splenoctomy. Later experiments showed that frog erythrocytes phagocytize erythrocytes of the rabbit, the chick, and man both in vitro and in vivo.(7)

When bacteria, erythrocytes, or serum of mammals were introduced subcutaneously into chicks, no phagocytosis could be observed. The difference between this finding and the results obtained on the frog may be due to the fact that in this case the injections were subcutaneous rather than into the lymphatic sack. However, when an experimental hemolytic disease, accompanied by stimulated regeneration of red blood, was induced in the chicks, their erythrocytes exhibited a pronounced capacity to phagocytize. Apparently young, rapidly formed erythrocytes retain the characteristics of a diversified cell which has not yet become highly specialized. When the blood of a normal chick is mixed with that of a ram, the erythrocytes of the chick phagocytize those of the ram.

To find out whether or not the erythrocytes of humans and other mammals are capable of carrying out phagocytosis, I investigated preparations from the blood-generating organs of children who died of erythroblastosis or some other hemolytic disease and of animals in which an experimental hemolytic disease was induced. In fact, I succeeded in detecting erythroblasts and normoblasts which phagocytized bacteria, cell fragments, and most frequently whole erythrocytes in cytograms of the spine of a puppy and a guinea pig in which I had induced a hemolytic disease with typical normoblastosis and erythroblastosis.

The question as to whether erythrocytes, which are devoid of nuclei, are capable of effecting phagocytosis arose next. After considering all available experimental data, I concluded that nonnuclear erythrocytes cannot carry out phagocytosis to the full extent because, with the loss of the nucleus, they have lost their characteristics as fully functioning cells.

At the same time, one may assume that bartonellosis and penetration of the malaria plasmodium into erythrocytes represent special forms of phagocytosis, the capacity toward which has been retained in the evolutionary process of the organism by erythrocytes devoid of nuclei. We refer to both the malaria plasmodium and the causative factor of bartonellosis as blood parasites, because the erythrocytes affected by them perish, not being able to overcome their toxins. According to M. K. Pokrovskaya (8), the same thing happens when segmentonuclear neutrophils phagocytize plague bacilli in pneumonic plague.

The phylogenesis of mammals, as every other evolutionary process, involves both phenomena of a progressive and regressive character. The ability of erythrocytes to effect phagocytosis is a regressive characteristic. Participating in the mechanism of immunity, nonnuclear erythrocytes of mammals evince traces of the characteristics which they had in the organism of the ancestors of the mammals. Basically, these erythrocytes have lost the ability to phagocytize.

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Although they have retained the ability to absorb the products of decomposition of proteins, they are no longer able to assimilate them. This is demonstrated by the experiments of B. Zbarskiy (9), who after boiling blood, the erythrocytes of which had adsorbed toxin, obtained almost the total quantity of toxin which was bound by the erythrocytes.

Further adaptation of the organism of mammals having nonnuclear erythrocytes led to intensified erythrophagocytosis in the spleen, spine, liver, lymphatic knots, and occasionally even in the peripheral blood whenever toxicosis arises (10). A multitude of erythrocytes loaded with toxins is phagocytized by leucocytes or cells of connective tissue (the reticuloendothelial system). In this process, the erythrocytes are destroyed together with the toxin which is bound by them. The relatively brief existence of the nonnuclear erythrocyte is reduced still further in toxicosis (11). When the erythrocyte is destroyed without participation of the phagocyte, it returns to the blood the toxin which it had taken up earlier. Intensified erythrophagocytosis prevents danger of a secondary flooding of the blood with toxins.

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